AN EVALUATION OF STUDENT LEARNING AND ENGAGEMENT IN A

TECHNOLOGY-ENHANCED ALGEBRA UNIT ON SLOPE

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The purpose of this study was to examine the effectiveness of a technology-enhanced unit on slope in algebra. The technology used in the study was the Topological Panorama Camera (Topocam). The research questions explored the learning and transfer of knowledge about slope and the engagement level of students during Topocam learning activities.

The Topocam is a computer-controlled camera that moves on a modular track while it scans a scene through a vertical slit. Students can program the speed of the camera and frequency of pictures. They then witness the results of time and motion in the image created by the camera.

Data for this study were collected from a pretest/posttest, as well as from observations of indicators of engaged learning. The research population consisted of 46 students from three classes of Algebra I students. Three classroom teachers each taught a unit on slope, while a fourth teacher conducted the activities with the Topocam for all the classes. The classroom activities focused on the concept of slope as a rate of change utilizing coordinate grids. The Topocam activities involved students in collaboratively making and testing predictions about slope.

The findings of the study indicate that student learning did occur with this technology-enhanced unit on slope in algebra. Students showed statistically significant improvement in understanding slope and in transferring that concept to other situations. Since technology was only part of the unit presentation, the amount of learning attributed to the Topocam activities cannot be determined. However, students demonstrated a high degree of engagement in learning while working with the Topocam which suggests that the activities were a factor. A low correlation between students' slope unit test scores and previous algebra performance may indicate that students who have not been successful in algebra were more successful in the technology-enhanced unit. Some variation was found between classes that could be attributed to other factors than the Topocam.

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TABLE OF CONTENTS

LIST OF TABLES AND FIGURES

CHAPTER I

INTRODUCTION

Criticism of the educational system for neglecting to prepare students for the realities of real-life work experiences has echoed from various national reports. These reports include A Nation at Risk: The Imperative for Educational Reform (National Commission on Excellence in Education, 1983), What Work Requires of Schools: A Secretary's Commission on Achieving Necessary Skills (SCANS) Report for America 2000 (1992), and the National Council of Teachers of Mathematics (NCTM) Curriculum and Evaluation Standards for School Mathematics (1989). Although A Nation at Risk bemoans American education, mathematics instruction was targeted in particular (Harvey et al., 1995). The SCANS report states that "more that half of our young people leave school without the knowledge or foundation required to find and hold a good job" (SCANS, 1992, p. v). In this report representatives from United States' schools, businesses, unions, and government identified workplace competencies and foundation skills that include mathematics and working with a variety of technologies. The SCANS report states that learning needs to be taking place in realistic environments, not by abstract manipulations. The NCTM Standards issue a call for reform in mathematics education. Integral to the Standards are the skills needed to be mathematically capable members of the workforce. These include the ability to work with others on problems, the ability to apply mathematics in problem situations, and a belief in the value of mathematics (Pollak, 1987). The current draft of the NCTM Standards 2000 Project states that "mathematics instructional programs should use technology to help all students understand mathematics and should prepare them to use mathematics in an increasingly technological world" (NCTM, 1998).

A basic consideration in preparing the Standards was the philosophy that "knowing" math is "doing" math. The continued innovation in computer technology and the impact of technology on society was also an important foundation in the NCTM recommendations. Expected student activities presented in the Standards focus on problem situations and active involvement with mathematics. The NCTM Curriculum and Evaluation Standards for School Mathematics (1989) list the following goals for students:

1. Learn to value mathematics
2. Learn to reason mathematically
3. Learn to communicate mathematically
4. Become confident of their mathematical abilities
5. Become mathematical problem solvers (p. 5-6)

A heightening concern over the level of mathematics achievement among students of the United States has been perpetuated by less than favorable studies on American mathematics education. Robitaille and Travers (1992) discuss international studies and comparisons such as the International Mathematics Studies, the International Assessment of Education Progress, and the Dallas Times-Herald Survey positioning the United States behind a number of other countries in math scores. These reports have yet to be reversed. Robitaille and Travers summarize further studies that investigated potential factors attributing to score differences. One such study, the Michigan Studies, noted that while U.S. children spent a majority of their classtime working alone, Asian classrooms spent more time with whole class discussion and interaction.

A theme underlying much research is the importance of applied problems to give meaning to abstract symbols. The National Assessment of Education Progress (NAEP) report results in 1986 indicated that students did poorly on fraction estimates, yet much better on questions requiring exact answers. This suggests that students had learned algorithms with little conceptual understanding of what they were doing. The results of the NAEP also indicated that many students thought that mathematics was rule-based and relied on memorization (Brown et al., 1988).

No single theory can completely describe how students learn algebra (Stiff et al., 1993), yet student engagement appears to be a significant factor. The Mathematical Sciences Education Board (1989) issued that "educational research offers compelling evidence that students learn mathematics well only when they construct their own mathematical understanding" (p. 58). Students should be "actively engaged in meaningful, hands-on, minds-on, authentic learning experiences in mathematics", not just receiving and remembering facts from the teacher (NCREL, 1989, p. 1). In algebra, the NCTM Standards specifically include the call for the use of real-world problems, computer technology, and instructional practices that reflect active engagement of students in solving problems. However, much of algebra instruction is still characterized by abstract manipulation of variables and numbers (L. McCoy, 1997; Harvey et al., 1995). If indeed algebra is "a way to model real-world phenomena and predict outcomes through manipulation of abstract symbols" as stated by Wagner and Parker (1993, p. 135), then should not real world phenomena be utilized in the instruction of algebra?

In 1929, Whitehead discussed what he called the inert knowledge problem. This refers to knowledge that is recalled only when people are directed to use that knowledge. He contended that inert knowledge is not used automatically when solving problems. He also stated that the information presented in schools is most likely done in a way that makes it inert. Campione (1990) refers to this as "blind" instruction, where students do not know why they are doing what they do. Direct instruction of algorithms occurs too frequently without helping students grasp the understanding of the math concepts (Harvey et al., 1995). Studies point to the effectiveness of problem-oriented approaches to learning in overcoming inert knowledge problems (Adams et al., 1988: Lockhart et al., 1988). In the context of situated learning, instruction is anchored in tasks that students and teachers can explore as experts would in the real world (Cognition and Technology Group at Vanderbilt, 1990). Sfard and Linchevski (1994) write that "algebraic symbols do not speak for themselves. What one actually sees in them depends on the requirements of the problem to which they are applied" (p. 191).

The National Commission of Excellence in Education stated in <u>A Nation at Risk</u> (1983) that computers and computer-controlled equipment are making their way into every aspect of life and that this technology is drastically changing the description of many occupations. Certainly the effect is even more dramatic seventeen years later. New technologies offer the possibility for students to learn the power technology affords for not only investigating mathematical relationships, but also for real-life problem solving (Duren, 1989). Computer technology is achieving a much wider dimension than simply an assistant for mathematical computations (R. Sutherland, 1991; Blum & Niss, 1991).

Technology has become part of as well as a solution to problems. Teachers face new challenges in working with equipment and in defining teacher/student roles (Means & Olson, 1994a). Technology can serve as a tool to expedite calculations and also as a problem-solving arena (Duren, 1989). Users of technology can discover new functions for technology use (Peck & Dorricott, 1994). Demanna and Waits stated in 1990 that educators would need to start preparing for the explosion of technology, encouraging students to discover new features of technology on their own and share their findings with the class. The NCTM Standards (1989) note the uncertainty of technology's role in teaching and learning. However, the NCTM 2000 Standards clarify the need for technology in education. Technology can support collaboration in a realistic problem-solving environment (Rossi & Montgomery, 1994). Technology has the potential of providing complex problems and meaningful work (K.L. Peck, 1994; Means et al., 1994). The use of technology as a tool for engaging students in projects that are relevant and challenging is thus, a reasonable path.

The reports and studies over the past two decades resonate some common themes for education. Preparing students to be productive members of the workforce is of major concern (SCANS, 1992). As society is becoming increasingly technological, this technology needs to be incorporated into education (NCTM, 1989; NCTM, 1998). Mathematics education should be situated in meaningful activity through the use of real-world problems (NCTM, 1989; NCREL, 1999), and engagement in learning is critical to algebra instruction (Stiff et al., 1993). The impact of mathematics technologies and their impact on students learning are very incomplete (Harvey et al., 1995). A new technological invention, the Topological Panorama Camera (Topocam), has the potential for engaging students in real world problem solving. As an authentic, challenging multidisciplinary technology, the Topocam has the potential to engage students in collaborative inquiry, mathematical thinking, and problem-solving.

Statement of Problem

Effective use of technology in education must provide challenging, authentic learning opportunities for students. As computer technology takes on new and varied forms, thus creating the opportunity for problem-solving situations, all students have the opportunity to learn cooperatively with authentic, challenging tasks. The Topocam offers such an experience. Continued research is warranted to examine these new technologies and their instructional effectiveness. Since no formal research has been conducted with the Topocam, this study evaluates this particular technology as an effective tool for use in teaching the concept of slope in algebra and for engaging students in learning.

Purpose of the Study

The purpose of the study was to analyze the use of the Topological Panorama Camera (Topocam) as an effective computer technology tool for use in algebra instruction. This exploratory study examined if an algebra unit on slope that is enhanced with the Topocam technology helped students understand the concept of slope and demonstrate this understanding by calculating slope using formulas and estimation. The study also examined if the technology-enhanced unit helps students transfer the concept of slope by recognizing and describing the concept in new situations. Student engagement in learning was also analyzed.

Research Questions

Three research questions were considered for this study:

1. Do high school Algebra I students understand the concept of slope by working with the Topocam in a technology-enhanced unit of study?

2. Do high school Algebra I students transfer the understanding of the slope concept to new situations by working with the Topocam in a technology-enhanced unit of study?

3. To what extent do students working with the Topocam in a technology-enhanced unit of study demonstrate engagement in learning?

Limitations

This study was limited by the characteristics of the population. The profile of the sample utilized is not generalizable to the general population of all students in the state or nation and will therefore require further research in order to establish valid generalizations. The study was not intended to produce definitive conclusions, but rather to provide impetus for further research.

Definition of Terms

The following definitions are provided to familiarize the reader with terms.

Topocam – The Topological Panorama Camera (Topocam) is a computer controlled camera that moves on a modular track while it scans a scene through a vertical slit. Students can program the speed of the camera and frequency of pictures. They then witness the results of time and motion in the image created by the camera.

Slope –The slope of a line is the rate of change of the ordinate (y) with respect to the abscissa (x), i.e. (in rectangular Cartesian coordinates) $y_1 – y_2 / x_1 – x_2$, where (x_1, y_1) and (x_2, y_2) are points on the line. Slope is not defined for lines perpendicular to the x-axis. (James & James, 1992, p. 386)

Summary

The search continues for improved mathematics instruction and the subsequent increase in student achievement. Availability and improvement of computer technology and computer-controlled equipment has most certainly has become a part of society and work. Not only will students need to be prepared to use these emerging technologies, the technologies themselves hold potential as an educational tool. This study evaluates the Topocam as an engaging example of a computer-controlled technology tool in learning algebra, specifically the concept of slope. Data on both student learning and student learning environment were collected and analyzed to answer the research questions using a unit test and classroom observations.

CHAPTER II

REVIEW OF LITERATURE

Since the technology used in this algebra unit, the Topocam, is a new technological invention, no formal research has yet been completed specifically with it. The research background specifically related to the Topocam is sparse; therefore, this review focuses on establishing a foundation of theory and research relating to student engagement and relating to technology use in education. The theories of Piaget and Vygotsky set the stage for meaningful student engagement in learning. This review begins with those theoretical underpinnings, followed by a more detailed look at engaged learning and situated learning. Next, a review of literature describes various forms of technology and the affect on student learning and attitudes. This section concludes with background information on the Topocam and its intended use in teaching algebra.

Theoretical Framework

The theories of Piaget and Vygotsky present a foundation for student learning and engagement. Jean Piaget identified four stages of cognitive development: the sensorimotor, the preoperational, the concrete operational, and the formal operational (Piaget, 1970). High school students often move between concrete operational and formal operational stages when new concepts are introduced and therefore need learning experiences that afford students the opportunity to manipulate objects and to make mathematical connections (Stiff et. al., 1993). Knowledge is acquired through constant interaction between the learner and the environment (Hersovics, 1989).

Crawford (1996) suggested that the ideas of Vygotsky are particularly relevant to this rapid era of change possibly due to the rapid changes of the post-revolutionary time in which he lived in Russia. Vygotsky looked at cognitive processes as being shaped by the social meaning of the artifacts and relationships within which learning takes place. Language that occurs within social interaction plays an important role in the construction of knowledge. Learning is therefore influenced by the social context and the environment created by technology, its capabilities, and the nature of the activity. Studies show that students view mathematics as simply a set of rules and techniques with the purpose of passing exams rather than constructing personal meaning in mathematics (Crawford et. al., 1993). Vygotsky's writings indicate a need for meaningful activity and personal involvement. According to Vygotsky, educational tools are cultural artifacts. Likewise, "using the technological tools of the professional community adds significance and cultural value to school tasks" (Means, 1994b, p. 202).

Technology

Much research literature finds newer technologies to be equal or better than conventional instruction (Bialo & Sivin, 1990). In a report by Means and numerous other individuals, the effects of technology on student achievement were addressed (1993). The research was organized in three categories. One category of studies compared technology media with conventional instruction and was labeled “horse race” studies. These studies included computer-assisted instruction, videodisc/multimedia technologies, and distance learning. Meta-analyses of this type of study at the secondary level have shown advantages for computer-assisted instruction (Bangert-Drowns, Kulik & Kulik, 1985; Kulik, Bangert, & Williams, 1983; Kulik & Kulik, 1989; Samson, Niemiec, Weinstein, & Walberg, 1986), particularly for disadvantaged and low-ability students (Bangert-Drowns, Kulik & Kulik, 1985; Samson, Niemiec, Weinstein, & Walberg, 1986). Another meta-analysis of 47 studies comparing conventional instruction to computer-controlled interactive videodisc (IVD) by Fletcher found positive results on achievement for the IVD groups (1990). The limitation of these types of studies was that they were plagued with uncontrolled variables, primarily that of content and instructional strategy. If re-evaluated, results may have not been so positive (Means et. al., 1993).

The second category of research suggested as a new emerging approach is contextualized research. This category focuses on examining and analyzing the relationships among the various elements and variables that could affect specific outcomes. Instead of comparing technology to other approaches, the way the student uses the technology or the culture of the classroom may be studied in addition to student performance. This suggests the use of a wider spectrum of methodologies in research. Numerous researchers using these more descriptive type studies have found positive effects of technology (Means et. al., 1993).

The Jasper Series, a technology-based program on laser disk, was the experimental variable in a contextualized research study conducted by the Cognition and Technology Group at Vanderbilt (1992). As an example of "anchored" instruction, the program generates learning by anchoring instruction in meaningful problems. The term "generative" refers to students generating meaning through active involvement rather than being involved in passive learning activities. Beneficial effects were found in student attitude, planning skills, and word problem solutions. Sixteen schools across nine states participated in the study including 739 students during the 1990-1991 school year. The Jasper videos pose a challenge to students after they have watched the 15-20 minute story. Clues to solving the dilemma are embedded within the video. The series includes seven basic design principles: video-based format, realistic problems, generative learning, embedded data, complexity, links across the curriculum, and related adventures.

Experimental studies are a third and important category of studies. They help investigate particular features of a new technology and the relationship to a particular aspect of student performance. An example of this type of analytical research includes research by Mokros and Tinker. In a three-month longitudinal study, they found microcomputer-based laboratories (MBLs) to reduce error in understanding slope when they were able to see the data graphed within a twenty second time period (1987).

In a report by the Software Publishers Association (1996), technology used in education has been found to have positive effects on student self-concept and student attitudes toward learning. Several elements were found to influence the effectiveness of the technology. Those elements include the student population, the software, the teacher's role, and the amount of student involvement. Generally the introduction of technology in the classroom has resulted in more cooperative learning and student/teacher interaction. The Software Publishers Association commissioned this report and used an independent educational technology consulting firm, Interactive Educational Systems Design, Inc. One hundred seventy-six research reviews and reports on original research projects dating from 1990-1995 were selected from over 1,000 studies for this report. Studies were eliminated from the analysis if the methodology was weak or if the topics did not relate to the report.

Much of research on technology in mathematics over the past fifteen years focuses on the graphing calculator (Hollar, 1996; Slavit, 1995). After the graphing calculator first appeared in 1986, research has been conducted on the effects on learning and attitudes of students that have used them (Harvey et. al., 1995). Research by Hollar compared a graphing approach algebra curriculum using the TI-82 graphing calculator with a traditional algebra curriculum (1996). Ninety students in one-semester college algebra courses participated in the study. A pretest/posttest design was utilized along with a department final exam and the Dutton Revised Mathematical Attitude Scale. Posttest results indicated that the graphing approach group gained a better understanding of functions, however there was no significant difference in performance on the department final, nor was a difference found in student attitudes toward mathematics.

A research conducted by Hopson looked at the effects of technology on the development of higher order thinking skills (1998). He found that a technology enhanced learning environment had a significant positive effect on the development of the higher order thinking skill of evaluation. The areas of analysis and synthesis were generally higher also. Student motivation and creativity and an awareness of computer importance also exhibited positive gains with the experimental group. The research was comprised of fifth and sixth graders using a district curriculum either with or without computers. The Ross Test of Higher Cognitive Ability and the Texas Center Educational Technology Computer Attitude Questionnaire were the test instruments. The author expressed concerns over the short duration of the study.

There is limited research on the impact of technology. Lookatch (1995) cautions that much of the limited research on technology and learning contains type I errors. He states that researchers have not controlled the many variables that may have caused the positive results. Yet according to the Software Information Industry Association's (SIIA) 1999 Education Market Report: K-12, the number of multimedia computers increased from 21.2 students per computer in 1997 to 13.5 in 1998. Drill and practice and problem-solving software programs are commonly used in mathematics. This explosion of technology in schools warrants careful investigation.

A report from the American Institutes for Research states that most studies examine behavioral and attitudinal changes, rather than actual effects on learning (Rossi & Montgomery, Eds., 1994). The report also touts many benefits to technology in education including immediate feedback for the student, increased student pride in high-quality products, flexibility in instructional strategies, and the preparation of students for a technology-rich workplace. In a survey of research, Smith concludes that how technology is implemented will affect its usefulness (1997). She also concludes that much of technology is new and therefore not subject to much research. Likewise, the software may be limited in availability that in turn limits long-term studies. Smith's research points out the importance of teacher training and continues to pose the importance of technology in creating representations that lead to mathematical understanding. Blum states that the computer is a powerful tool for numerical and graphical calculations, however there is a new trend toward computer technology that models and applies mathematics to different areas (1991).

A framework for technology effectiveness has been developed Jones, Valdez, Nowakowski, and Rasmussen (1994). The analytic variables for the framework stem from the indicators for engaged learning and instructional reform developed by Means in 1993. Means argues that authentic tasks are the primary indicator. If learning tasks are authentic then all other indicators will fall in place. (See Table 1) Technology implementation naturally leads to more complexity in instruction with the teacher assuming a coaching style. Jones and his colleagues (1994) note several strands of research that have led to an emerging consensus on learning and technology. These strands include anchored instruction, metacognition and cognitive apprenticeship.

Engaged Learning

Means (1993) made the argument that the effectiveness of technologies should be measured by the degree that they support engaged learning. Engaged learning is not based on one particular teaching model, but rather a number of models and strategies that engage students in learning. Jones et al. (1994) list the following engaged learning indicators in Table 1. A glossary for this table is located in Appendix A. The asterisk denotes the indicators originally provided by Means and her colleagues (1993).

Poor educational performance has been shown to result when students become disengaged from the education experience (Finn, 1989; Kelly, 1989; Merchant, 1987; Rumberger, 1987; Natriello, 1984). Participation and success in school activities are important in avoiding academic failure. Preliminary signs of disengagement are disruptive behavior and poor attendance (Rossi et al., 1994).

Table 1

Engaged Learning and Reform Instruction

Variables of Learning and Instruction	Indicator for Engaged Learning and Reform Instruction
Vision of Engaged Learning	Responsible for Learning Energized by Learning Strategic Collaborative
Tasks	Challenging* Authentic* Integrative/interdisciplinary*
Assessments	Performance-Based* Generative Interwoven with Curriculum and Instruction Equitable Standards
Instructional Models	Interactive* Generative Learning Context for Engaged Learning
Learning Context	Collaborative* Empathetic
Grouping	Heterogeneous* Flexible Equitable
Teacher Roles	Facilitator* Guide Co-Learner and Co-Investigator
Student Roles	Explorer* Cognitive Apprentice Producers of Knowledge

Note. From Designing Learning and Technology for Educational Reform (p. 16), by B. F. Jones, G. Valdez, J. Nowakowski, and C. Rasmussen, 1994, Oak Brook, IL: NCREL. Copyright 1994 by NCREL. Reprinted with permission.

A study by McDonald showed positive results when students are engaged in learning (1998); however, some teachers had negative feelings about the level of noise and activity involved. A variety of teaching strategies are utilized that engage students in active problem solving and inquiry. Additionally, interaction with peers and the teacher contributes to the construction of new knowledge (Yackel et al., 1990). These interactions allow students to verbalize, justify, and clarify solutions, thus adding depth to understanding. Lampert further testifies that the most ideal learning environment is a collaborative classroom (1989). This type of learning and teaching theory is not without its problems. The activities of the teacher and the actual learning of the students are more difficult to measure and describe (Cobb, 1988; Lampert, 1990).

Situated Learning/Cognitive Apprenticeship

Cognitive apprenticeship refers to the use of the reasoning processes that experts use to develop strategies and solve complex problems (Collins et. al., 1991). Collins explains that just as traditional apprenticeships enable a student to learn from actual experience skills from an expert, cognitive apprenticeship refers specifically to learning cognitive processes utilized by an expert. Cognitive apprenticeship also differs from traditional views of apprenticeship in that the cognitive skills are intended to transfer to diverse settings. These thought processes must occur as closely as possible to those the expert would encounter in real situations. If the classroom activities are situated in meaningful, authentic tasks, the learner has the opportunity to experience this type of cognitive apprenticeship. In situations that are similar to tasks that arise in real life, the teacher and then the student models thinking processes (Collins et al., 1991). Many techniques exist for revealing thinking processes and providing a scaffolding for students' development of these processes, such as reciprocal teaching (Palincsar et al., 1984) and the process outlined by Scardamalia and Bereiter of modeling, coaching, scaffolding and fading (1984). The term "situated" refers to grounding the learning activity within the school curriculum in ways that students can understand that learning is transferable. In order to relay this message, a wide range of tasks must be used to show common processes (Collins et al., 1991). Principles for designing cognitive apprenticeship environments are outlined in Table 2 (Collins et al., 1991).

The concept of situated learning is not new. John Dewey used situated learning in the early 1900's by having the students build a clubhouse in order to learn arithmetic and planning skills (Cuban, 1984). This philosophy is echoed in the 1989 and 2000 NCTM Standards. The Standards issue a request for increased attention to the use of real-word problems in order to motivate students and help them apply theory. The NCTM 2000 Project (1998) continues the theme stating that the use of mathematics in applied situations will result in deeper understanding on the part of the student (Standard 9: Connections).

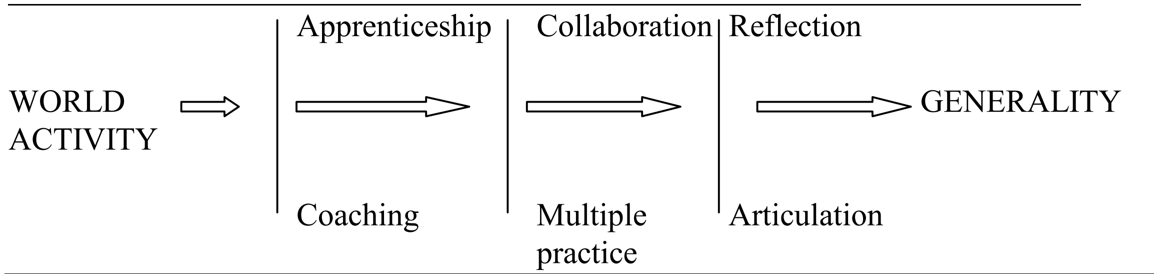
Table 2

Principles for Designing Cognitive Apprenticeship Environments

CONTENT *types of knowledge required for expertise*
Domain Knowledge *subject matter specific concepts, facts, and procedures* Heuristic strategies *generally applicable techniques for accomplishing tasks* Control strategies *general approaches for directing one's solution process* Learning strategies *knowledge about how to learn new concepts, facts, and procedures*
METHOD *ways to promote the development of expertise*
Modeling *teacher performs a task so students can observe* Coaching *teacher observes and facilitates while students perform a task* Scaffolding *teacher provides supports to help the student perform a task* Articulation *teacher encourages students to verbalize their knowledge and thinking* Reflection *teacher enables students to compare their performance with others* Exploration *teacher invites students to pose and solve their own problems*
SEQUENCING *keys to ordering learning activities*
Global before local skills *focus on conceptualizing the whole task before executing the parts* Increasing complexity *meaningful tasks gradually increasing in difficulty* Increasing diversity *practice in a variety of situations to emphasize broad application*
SOCIOLOGY *social characteristics of learning environments*
Situated learning *students learn in the context of working on realistic tasks* Community of practice *communication about different ways to accomplish meaningful tasks* Intrinsic motivation *students set personal goals to seek skills and solutions* Cooperation *students work together to accomplish their goals*

Note. From "Cognitive Apprenticeship: Making Thinking Visible," by A. Collins, J. S. Brown, and A. Holum, 1991, American Educator, 91(3), p. 43.

Brown and his colleagues contend that activity is not separable from learning (1989). Thus lies the association of “knowing” and “doing”. Brown and his colleagues also emphasize modeling and scaffolding, with authentic activity as the basis for situating learning (1989, see Figure 1). Students associate the situations and activities utilized in instruction to the usefulness of that knowledge in the real world. The culture of a society serves to frame the realm of meaningful activity (Brown et al., 1989; Orey et al., 1994). Knowledge is more useful and more powerful when acquired in a specific situated activity than when presented in an abstract fashion (Orey et al., 1994). Classroom tasks, however, may be foreign to authentic activity, or the practices of a culture, resulting in the miscommunication of outcomes to the student. The student may see learning as solely for performing on tests.



Note. From “Situated Cognition and the Culture of Learning,” by J. S. Brown, A. Collins, and P. Duguid, 1989, Educational Researcher, 18(1), p. 39.

Figure 1. Students’ progress from Embedded Activity to Generality.

Collaboration is an important principle in cognitive apprenticeship. Resnick states that people learn and work collaboratively throughout most of their lives, not individually as they are asked in many schools (1988). Therefore, collaboration should be seen as the practice of the culture or one way to situate learning. Collaborative environments also lead to the opportunity for sustained exploration of thinking processes. Orey and Nelson (1994) believe that sustained exploration is very important and can be facilitated by technology.

Background on the Topocam

The Topological Panorama Camera, nicknamed the Topocam, is a recent (1990 patent public) invention of the Gelphman Camera Company, Inc. (GCCI). The inventor, Janet Gelphman, created this camera based on the technology of the panoramic camera, using a slit to collect thousands of lines of data. The Topological Panorama Camera (Topocam) is a computer controlled camera that moves on a modular track while it scans a scene through a vertical slit. Students can program the speed of the camera and frequency of pictures. They then witness the results of time and motion in the image created by the camera. The Topocam offers new and varied multi-disciplinary connections, including mathematics, science, physics, and art. In essence, the camera makes motion visible.

Some physics and mathematics instructional materials using the Topocam have already been developed. Dr. Richard P. Olenick, professor and chair for the department of physics at the University of Dallas, has stated that the Topocam provides "new parallels to physical phenomena", and he is excited about the possibilities for the camera. The informal feedback from schools using the camera has been positive (online: http://129.120.20.20/topocam/finalEva.htm). GCCI also provides a consortium as a resource for its member schools. All of these activities are very new.

Summary

Numerous studies have shown the need to involve students in meaningful authentic learning tasks at all levels of instruction. Barbara Means has further stated that these authentic tasks are the key to engaging students in learning. Computer controlled technologies have become an integral part of our society and therefore provide meaningful activity for learning experiences. Limited research has shown that the use of technology can impact learning and attitudes about learning in a positive way, especially when the technology is anchored in meaningful tasks. Technologies, such as the Topocam, hold promise for use in algebra instruction and for preparing students for a changing technological workplace.

CHAPTER III

METHODOLOGY

This study was designed to examine the effectiveness of a technology-enhanced unit on slope on students' understanding of the concept of slope. The technology employed in the unit was the Topological Panorama Camera (Topocam). The research questions concern the students' ability to understand the concept of slope and to transfer that learning to other situations. Students' level of engagement was also examined.

This chapter provides a detailed explanation of the instruments and research methods used in this study. The chapter consists of seven sections: Research Design, Subjects, Ethical Standards, Instructional Procedures, Data Collection, and Data Analysis Procedures.

Research Design

Students' understanding and transfer of the concept of slope were evaluated using a pretest/posttest design. The same teacher-made test served as both the pre-test and the post-test. This design shows if learning actually takes place. The classroom teachers constructed the test. The amount of learning attributed to the Topocam activities necessarily becomes a topic for further research. The pre/posttest was divided into two sections. One section was designed to measure student understanding of slope values and the other section includes questions indicating transfer of slope to other situations. The research took place at the beginning of the second semester of a two-semester algebra course. An algebra unit on slope was taught, enhanced with activities using the Topocam. A time measure observation was employed to look at indicators of engagement. The observations of indicators of engaged learning provide evidence that learning could be attributed to the Topocam activities since engagement has proven to be critical in algebra instruction (Stiff et al., 1993). Students of three Algebra I sections at a secondary school in an urban Texas school district comprised the population.

All classes studied the same topics in a fifteen-hour unit on slope and related content. The classes met for 90 minutes every day. The teachers of the classes presented the same lesson plans for the unit enhanced with Topocam activities. A detailed outline of the unit and the Topocam activities is described in Appendix B, C, and D. The unit was designed and evaluated by the teachers. The use of three classrooms allowed the researcher to see if the results were replicated (Gall et al., 1996).

Subjects

The group of students studied consisted of three classes of secondary school students that were enrolled in Algebra I classes. Student ages ranged from 14 years to 17 years. These students would be classified as a convenience sample since they were selected because they are easily accessible (Gall et al., 1996). These classes met 90 minutes every day all year. The extra time allowed for more exploration and interaction. Students were assigned to the classes using a computer-generated master schedule and qualified for the class if they had not passed the eighth grade math portion of the Texas Assessment of Academic Skills (TAAS) test or if they had not passed the regular Algebra I course. Although not a subject of this study, the demographics of the groups were viewed.

Three classes were used, with forty-six students participating in the study. The breakdown of characteristics of student participants is in Table 3.

Table 3

Subjects

		Sex		Age				Ethnic Breakdown			
Group	# of students	F	M	14	15	16	17	White	Black	Hispanic	Other
1	15	9	6	0	7	5	3	7	2	6	
2	15	5	10	3	6	5	1	6	5	4	
3	16	6	10	3	7	6	0	5	4	6	1
Total	46	20	26	6	20	16	4	18	11	16	1

Ethical Standards

Approval of the Human Subjects conditions were met and approved by the Institutional Review Board of the University of North Texas. Additionally, permission to conduct the study was secured from the Assistant Superintendent of Instruction for the school district and of the Principal of the secondary school.

All students above the age of 14 that participated in the study signed a consent form allowing the data to be used in the study. They also received a copy of the consent form to keep. Students that were still 14 years old had their form signed by their parents. Individual information was used only for matching pre- and posttest data. Final analyses and reporting were conducted using only group data, protecting the individual identities. This study was conducted in an established educational setting, involving normal educational practices.

Instructional Procedures

Enrichment activities with the Topological Panorama Camera (Topocam) were used in combination with a unit on slope in Algebra I. Three classroom teachers each taught the core unit on slope, while the Topocam activities were conducted by a fourth teacher. Unit activities are detailed in Appendices B-D. The three classroom teachers served as content experts for the lesson materials and the fourth teacher as the content expert for the Topocam activities. The teachers reviewed the lesson materials for content validity and accuracy. The unit begins and ends with whole class activities associated with the Topocam. In between those days students participated in investigations on the Topocam in small groups. The Topocam was set up in a technology-type lab setting and was available during classtime only. The small groups left the regular class one group at a time for the Topocam activities while the rest of the class worked on lessons in the classroom. Whole class activities were designed to teach the concept of slope as a rate of change and as the change in y over the change in x through analysis of graphs on coordinate grids. The Topocam activities focused on working collaboratively to make predictions and then test their predictions about slope using the Topocam. For example, students began with a baseline image (Figure 2). They predicted the outcome of the image if the speed of the Topocam was doubled or halved. Illustrations of the experiment results are presented in Figures 3 and 4. The unit concluded with small group presentations to other groups in the class.

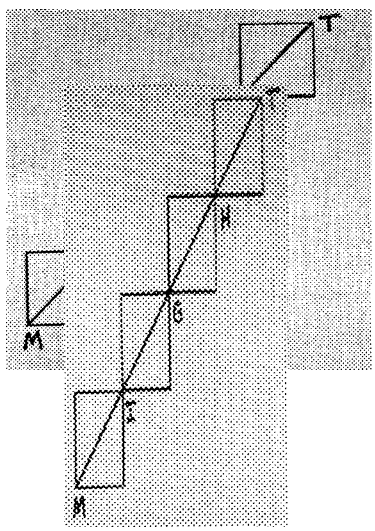


Figure 2. Baseline image taken at 10.5 cm/sec.

Figure 3. Image created by increasing the Topocam speed to 21 cm/sec.

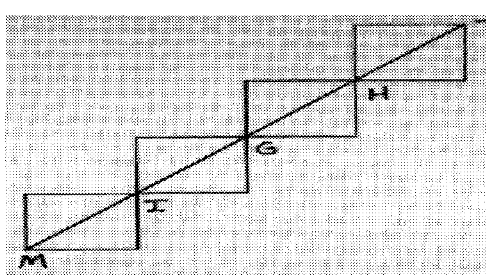


Figure 4. Image created by decreasing the Topocam speed to 5.25 cm/sec.

Data Collection

Two instruments were used to collect information in the study: the pretest/posttest, and the indicators of engaged learning checklist. A discussion of each of these follows.

The Unit Tests.

A unit test over slope and related concepts served as both pre-test and post-test. The classroom teachers served as content experts in developing this instrument. Little contamination should have resulted since the results of the pretest were not given to the students. The test can be found in Appendix E. The test was divided into two parts. One part included questions pertaining to understanding slope as change in y over change in x. Questions included positive and negative values, as well as relative values. The transfer of slope to other situations was measured through the last two essay questions where students described what could be happening in a graph.

Classroom Observations.

The researcher observed five different groups during the unit. The observations focused on the indicators of engaged learning while using the Topocam. An Engaged Learning Checklist was used to check for the indicators of engaged learning at ten-minute intervals within a thirty-minute observation. Each ten-minute period the observer went through the checklist for presence of each indicator. This checklist is from the Indicators of Engaged Learning (NCREL, 1995) and is located in Appendix F. Two classroom teachers also completed the checklist at different times from the researcher and then participated in an interview with the researcher in order to clarify the descriptive data pertaining to the engagement of students while using the Topocam. Frequency as well as written examples of the observations are a part of the engaged learning indicator checklist. Data from the Engaged Learning Checklist is descriptive.

Data Analysis Procedures

The slope pretest/posttest scores were analyzed by looking at the range and mean of the pretest and posttest. The difference between the pretest and posttest was then calculated in order to obtain the mean gain in each area. Per cent of gain is also used as a descriptive figure. A one-sample t-test was performed on the mean gain (Hinkle, 1994). The t distribution is appropriate for small samples (Thomas & Young, 1995). The Pearson product-moment correlation coefficient was used to examine the correlation between student performance on the slope unit and their performance in algebra prior to this unit. Their first semester average was used to represent prior performance in the class. The final analysis was between classes. Since three separate classes of students participated in this study, they were compared against one another. The mean gains of each class in both sections of the test were compared. Levene's test for equality of variances and a t test for equality of means were run on the comparison data, assuming homogeneity of variance and normal distribution. Statistical Package for the Social Sciences (SPSS) for Windows software was used to analyze the quantitative data. The following data were entered:

- Class (one of three)

- Student number for matching purposes
- Score on pretest for understanding slope
- Score on posttest for understanding slope
- Score on pretest for transferring slope
- Score on posttest for transferring slope
- Past semester Algebra average

To examine engagement in learning, frequencies of the indicators were identified using a table. A summary of the observers' descriptions of engaged learning indicators was compiled in order to support the presence of the indicators observed.

Summary

The data collection and analysis procedures in this study are focused on evaluating student learning and engagement in a technology-enhanced algebra unit on slope using the Topocam. Student learning includes the understanding and the transfer of the concept of slope as measured by a pretest/posttest. Observations using an engaged learning checklist were utilized in an effort to look at indicators of engaged learning. This analysis of engaged learning is considered pertinent to the evaluation of technologies in education (Means, 1993) and learning in algebra (Stiff et al., 1993).

CHAPTER IV

DATA ANALYSIS

This chapter contains the data analyses and results from this research. An analysis of the pretest/posttest data was used to determine if indeed learning did take place. The observation of indicators of engaged learning are considered pertinent to attributing learning to the presence of the technology used in the unit on slope.

The chapter is divided into two major sections. The first section presents the data and analysis of the pre/posttests. Section two discusses the findings of the engaged learning observations. Research questions are stated in the appropriate sections. A discussion based on the data analysis is given in Chapter 5.

Pre/Posttest Data and Analysis

Research Questions One and Two

1. Do high school Algebra I students understand the concept of slope by working with the Topocam in a technology-enhanced unit of study?

2. Do high school Algebra I students transfer the understanding of the slope concept to new situations by working with the Topocam in a technology-enhanced unit of study?

The students' learning was analyzed by comparing the mean gain from pretest to posttest. Tables 4 and 5 show the ranges, means, standard deviations, and per cent gains for the two sections of the test. Table 6 calculates the mean gain from the data in Tables 4 and 5. By comparing these means it is a reasonable conclusion that learning did take place. The mean score increased 78.846% from the pre to the posttest on the portion of the test on understanding slope. The mean on the transfer of slope section increased by 77.134%. The data show evidence that learning did take place pertaining to research questions one and two. High school students gained an understanding of slope and transferred the concept of slope to new situations by working with the Topocam in a technology-enhanced unit on slope. A one-sample t test (Table 7) shows a confidence level indicating that in less than one time in a thousand would this improvement have occurred by chance.

Table 4

Means and Standard Deviations for the Pretest and Posttest for Understanding Slope

	Minimum	Maximum	Mean	SD	Gain %
Pretest	0	35	8.130	8.350	
Posttest	1	69	38.435	18.487	78.846%

N=46

Table 5

Means and Standard Deviations for the Pretest and Posttest for Transferring Slope

	Minimum	Maximum	Mean	SD	Gain %
Pretest	0	2	.189	.492	
Posttest	0	2	.826	.732	77.134%

N=46

Table 6

Difference from Pretest to Posttest

	Mean	SD	Standard Error of the Mean
Diffcomp	30.304	18.630	2.747
Difftran	.644	.773	.115

N=46

Diffcomp = difference between the mean pretest score and the mean posttest score on the comprehension part of the test.

Difftran = the difference between the mean pretest score and the mean posttest score on the transfer portion of the test.

Table 7

One-sample t test

	t	df	Significance (2-tailed)
Pre-Post Comprehension	11.033	45	.000
Pre-Post Transfer	5.590	45	.000

N=46

The Pearson product-moment correlation coefficient (Table 8) was used to examine the correlation between student performance on the slope unit and their performance in algebra prior to this unit. Their first semester average was used to represent prior performance in the class. The correlation between semester grade and pre/posttests is very low. In other words, a student with a low semester average did not necessarily score low on this unit test.

Table 8

Correlations

	Semester Grade	Diffcomp	Difftran
Semester Grade			
Pearson Correlation	1.0	.059	.242
Significance (two-tailed)	-	.699	.109
Diffcomp			
Pearson Correlation	.059	1.0	.197
Significance (two-tailed)	.699	-	.189
Difftran			
Pearson Correlation	.242	.197	1.0
Significance (two-tailed)	.109	.189	-

N=45

By observing the difference in mean gains for the three classes from pretest to posttest there is evidence that not all classes showed similar improvement (Tables 9 and 10). Table 9 shows the number of students in each class, the mean gain, standard deviation, and standard error of the mean for each class on the portion of the test on understanding slope. Table 10 shows the same information for the part of the test on transferring the concept of slope.

Mean gains in Tables 9 and 10 indicate that Class 3 has a visibly higher mean gain than the other two classes on the understanding portion of the test and Class 2 has a visibly lower mean gain than the other two classes on the transfer section. An independent samples t test for equality of means was used to check the significance of those differences (Table 11). Levene's test for equality of variances was used to check that assumptions of the t test were met. Levene's test is appropriate with small samples since it is less sensitive to nonnormality in data (Snedecor & Cochran, 1989). The only t value that is of significance is Difftran 2-3. That score indicates that the difference in means between Classes 2 and 3 is statistically different on the transfer portion of the test.

Table 9

Group Statistics: Improvement on Understanding

Class	n	Mean	SD	Std. Error of The Mean
1	15	27.333	16.185	4.179
2	15	28.333	21.463	5.542
3	16	34.938	18.197	4.549

Table 10

Group Statistics: Improvement on Transfer

Class	n	Mean	SD	Std. Error of The Mean
1	15	.786	1.032	.259
2	15	.333	.556	.144
3	16	.813	.629	.157

Table 11

Independent Samples Test

Comparison Groups	Levene's Test for Equality of Variances		t-test for Equality of Means			
	F	Sig.	t	df	Sig. (2-tailed)	Mean Difference
Diffcomp 1-2						
Equal variances assumed	2.088	.160	-.144	28.000	.886	-1.000
Equal variances not assumed			-.144	26.031	.887	-1.000
Diffcomp 1-3						
Equal variances assumed	.551	.464	-1.226	29.000	.230	-7.604
Equal variances not assumed			-1.231	28.927	.228	-7.604

Diffcomp 2-3 Equal variances assumed Equal variances not assumed	 .632	 .433	 -.926 -.921	 29.000 27.550	 .362 .365	 -6.604 -6.604
Difftran 1-2 Equal variances assumed Equal variances not assumed	 2.899	 .100	 1.483 1.454	 27.000 19.660	 .150 .162	 .452 .452
Difftran 1-3 Equal variances assumed Equal variances not assumed	 1.562	 .222	 -1.226 -1.231	 28.000 20.908	 .931 .934	 -2.68E-02 -2.68E-02
Difftran 2-3 Equal variances assumed Equal variances not assumed	 .580	 .452	 -2.240 -2.249	 29.000 28.909	 .032	 -.479 -.489

Engaged Learning Data and Analysis

Research Question Three

3. To what extent do students working with the Topocam in a technology-enhanced unit of study demonstrate engagement in learning?

Table 12 summarizes the observations of engaged learning by the researcher and teachers. There were a total of seven thirty-minute observations. Each of the seven observations was with a different group. The thirty-minute observations were further divided into ten-minute intervals, resulting in a maximum of 21 possible occurrences for each indicator. Not all indicators are necessarily present at all times, neither is there research to show that they should be all present at all times. The results show that indicators of engaged learning were present during the Topocam activities. Twenty-five of the twenty-six indicators were frequently observed.

Table 12

Observations of Engaged Learning and Field Notes

Variable	Indicator for Engaged Learning	*	Descriptions from Observers
Vision of Learning	Responsible for Learning	11	(1)Students were asked to select their own standards for the task , starting and stopping points, lighting/(3)A student asked a question about his pictures tha didn't pertain to the targeted object
	Strategic	10	(1)Students evaluated the quality of the product, analyzed the difference in products, documented the difference in products and the data involved
	Energized by Learning	17	(1)Students were on task and focused on the activity
	Collaborative	19	(1)Each student had their role in the activity/ Students were clustered together to see the results
Tasks	Authentic	15	(1)The experiments showed change in slope related to the speed of the camera/ The experiments showed real-world phenomenon/ Experiments resulted in a photographic representation
	Challenging	21	(2)The team judged the quality of the picture and choose how to adjust. This was challenging, but not frustrating/ (1)Students were on task, actively assuming their job/ Students appeared to be concentrating, but did not give up/ (3)All students were attentive the entire time. All were interested and became successful.
	Multidisciplinary	16	(1)Activity involved mathematics, computer operation, photography (adjusting the camera), teamwork, writing observations/record-keeping

Assessments	Performance-Based	16	(1)Students decided where to program the start and stop points for the camera/ (2)Students produced pictures/ (1)Students had roles in producing the pictures/ (2)Students produced pictures to aid their own learning and will eventually present for others
	Generative	13	(1)Students assess the quality of the picture/ Students made predictions about how the picture would turn out at a different speed and the analyzed the accuracy of their prediction for the actual picture
	Seamless and ongoing	16	(1)Students showed surprise at the difference between their prediction and the actual photo/(3)Instructor used the groups answers about questions from their pictures to explain shapes in their pictures, students continued to ask questions
	Equitable	14	(1)Students decided if they were satisfied with the results/ Everyone in the group shared their observations
Instructional Models	Interactive	16	(2)Students made choices on changing the programming of the robotic camera to test their own ideas
	Generative	18	(1)Student showed surprise at the results of the experiment/ Experiment constructed to determine what happened and why
Learning Context	Collaborative	19	(1)Each had a different job/ Activities continuously done with small group work/ Student asked a question of another student/ The computer operator helped the next computer operator to do that job/ (3)Students discussed similarities and differences in the pictures
	Knowledge-building	11	(1)Students predict and then they see the actual results/ (2)Students make different decisions each time they rotate jobs & gain knowledge from each other's experience
	Empathetic	15	(1)Students shared ideas/ Students made choices, including team name
Grouping	Heterogeneous	20	(3)Groups included male & female, also different ethnic groups/ Academic ability was varied
	Equitable	20	(1)Jobs were assigned and each student did every job once/ Each student was responsible for his/her job
	Flexible	0	(1)Students stayed with the same group during this unit

Teacher Roles	Facilitator	18	(1)Teacher asked students to make their own choices, start and stop position/ Teacher taught first job rotation, student taught the next person with that job/(3)Instructor encouraged good observations from group and asked questions that expanded on those findings
	Guide	16	(1)Teacher asked students questions about what would happen if they started the camera in a different place/ (2)Teacher was available, but not controlling/ Teacher modeled task for the first time/ Teacher left many decisions to the students, such as lighting/ Teacher valued student responses and let students judge success
	Co-Learner/Co-Investigator	9	(1)Student asked what would happen, teacher said "I don't know, we'll have to try that and find out"
Student Roles	Explorer	10	(2)The Topocam and computer were new to students as a way to learn math/ (3)(1)Students asked questions about what would happen if other changes were made to the speed of the robotic camera/ (1)Students made predictions and then tested their predictions/ Students discovered reasons for slope change
	Cognitive Apprentice	14	(1)Students researched predictions/ Students collected and recorded data/ Students documented predictions and results
	Teacher	10	(1)Computer operators taught the next computer operator the program/ Students helped successive students with their jobs
	Producer	12	(2)Students were on task and interested/ Students created a picture

*total number of times observed out of 21 possible time intervals

(1) is followed by statements made by the researcher from observations

(2) is followed by statements made by the first teacher observer

(3) is followed by statements made by the second teacher observer

The Engaged Learning Checklist had a description section to gain insight into the reasons for checking that an indicator was present. A high degree of engagement of students is supported by the frequency of almost all indicators in the unit. The only indicator not observed was "flexible grouping". Students did not rotate to different groups in this unit.

Table 13

Frequency of Engaged Learning Indicators in Observations

Rank	Variable	Indicator	Frequency
1	Tasks	Challenging	21
2	Grouping	Heterogeneous	20
3	Grouping	Equitable	20
4	Learning Context	Collaborative	19
5	Instructional Models	Generative	18
6	Teacher Roles	Facilitator	18
7	Vision of Learning	Energized by Learning	17
8	Tasks	Multidisciplinary	16
9	Assessments	Performanced-based	16
10	Assessments	Seamless & Ongoing	16
11	Instructional Models	Interactive	16
12	Teacher Roles	Guide	16
13	Tasks	Authentic	15
14	Learning Context	Empathic	15
15	Assessments	Equitable	14
16	Student Roles	Cognitive Apprentice	14
17	Assessments	Generative	13
18	Student Roles	Producer	12
19	Vision of Learning	Responsible for Learning	11

20	Vision of Learning	Collaborative	11
21	Learning Context	Knowledge-building	11
22	Vision of Learning	Strategic	10
23	Student Roles	Explorer	10
24	Student Roles	Teacher	10
25	Teacher Roles	Co-learner/Co-investigator	9
26	Grouping	Flexible	

Table 13 presents the indicators of engaged learning according to the frequency that they were observed. The most observed indicator was “challenging tasks”. This indicator was checked by every observer during every time interval. The next most observed indicators were “heterogeneous grouping” and “equitable grouping”. Eighteen of the indicators were observed more than half of the time intervals, including “authentic tasks” which are critical to the entire engaged learning process (Jones et al., 1994).

CHAPTER V

CONCLUSIONS AND RECOMMENDATIONS

This study includes methods to evaluate student engagement and learning in a technology-enhanced algebra unit on slope. The technology employed was the Topocam, a computer controlled camera. Student learning investigated included the ability to understand slope and to transfer the concept of slope to new situations. The presence of 25 of 26 indicators of engaged learning is considered strong evidence of active learning taking place during observed activities. This chapter contains the conclusions and implications of the results presented in the previous chapter.

This final chapter is divided into six sections. The first section is a summary of the study. Conclusions relating to the results of the study are presented in the second section. The third section connects the findings with the research presented in chapter two. Section four presents the limitations of the study, followed by implications for the classroom, and suggested recommendations for further research.

Summary

The purpose of this study was to examine the effectiveness of a technology-enhanced unit on slope in algebra. The technology used in the study was the Topological Panorama Camera (Topocam). The research questions explored were based on the need for avenues that allow students to understand and transfer mathematical concepts.

Data for this study were collected from a pre/posttest, as well as from observations of indicators of engaged learning. The observations were conducted by the researcher and two other teachers. The pre/posttest included a section on understanding the concept of slope and a section on transferring the concept of slope. The research population consisted of forty-six students from three Algebra I classes. All students participated in a unit on slope that included activities using the Topocam. The regular classroom teachers taught the unit on slope, while a fourth teacher conducted the activities with the Topocam for all the classes. The classroom activities focused on the concept of slope as a rate of change utilizing coordinate grids. The Topocam activities involved students in working collaboratively to make and test predictions about slope.

The data indicate that a statistically significant gain was made from pretest to posttest in both understanding and transfer of the slope concept. Also, many of the 26 indicators of engaged learning were observed regularly.

Conclusions

Research Question 1. Do high school Algebra I students understand the concept of slope by working with the Topocam in a technology-enhanced unit of study?

Research Question 2. Do high school Algebra I students transfer the understanding of the slope concept to new situations by working with the Topocam in a technology-enhanced unit of study?

Pretest/posttest gains on both the understanding and transfer sections indicate that learning did take place. A one-sample $\underline{t}$ test indicated that the mean gain from pretest to posttest is statistically significant beyond the .001 significance level, $p=.000$. The degree to which the Topocam is responsible for those gains in not determinable from this data. However, results from the Engaged Learning Checklist would support that learning did take place while doing the Topocam activities since engagement has been indicated as critical to learning algebra (Stiff et al., 1993).

Research Question 3. To what extent do students working with the Topocam in a technology-enhanced unit of study demonstrate engagement in learning?

All indicators of engaged learning except flexible grouping were regularly observed during the unit Topocam activities, with students engaged in challenging tasks being the most observed indicator. Heterogeneous and equitable grouping were the next most observed indicators. Eighteen of the twenty-six indicators were observed during more than 50% of the time intervals. Therefore, students demonstrated a high degree of engagement in learning while working with the Topocam in this technology-enhanced unit.

Other observations suggest that other factors may have affected the learning process. Low correlation between test data and semester grades presents possible questions. Students with a low semester average did not necessarily score low on the unit test. This could be related to the presence of the Topocam. Also, there was some evidence of variation between classrooms on pretest to posttest mean gains. Only the difference between classes 2 and 3 on the transfer section of the test was found statistically different. This provides some evidence that other factors besides the Topocam were involved. A possible factor that could have contributed to the difference may have been the classroom teacher. Other factors contributing to the learning process warrant further investigation.

Connections to the Literature

This study sought to investigate the use of a technology for instruction and the engagement of students in learning while using that technology. Research observations relate to the literature presented in chapter two. Since the research on the impact of computer technology on student learning is incomplete (Harvey et al., 1995), a basis was set for investigating this technology through research and theory related to mathematics, technology, and algebra instruction. Included is the importance of student engagement in the learning process (Stiff et al., 1993; Means, 1994). Students learn well when they construct meaning (MSEB, 1989) and have the opportunity to manipulate concrete materials (Piaget, 1970). Along with this involvement with authentic tasks (Means, 1994) is the importance of social interaction (Crawford et al., 1993). In a social environment students have the opportunity to verbalize their thinking, compare performance with others, and pose and solve their own problems (Collins et al., 1991). Educational tools gain meaning when they are a meaningful part of the culture of a society. Society is experiencing rapid technological advances and these technologies are avenues for students to construct personal meaning. Instruction should be situated in meaningful activity (NCTM, 1998: Brown et al., 1989; Orey et al., 1994).

Findings in this study show that the students' improvement in understanding and transfer of the slope concept after working with the Topocam in a technology-enhanced unit on slope was statistically significant. This supports research done with other technologies, such as the graphing calculator (Hollar, 1996). Computer technology has generally been shown to be effective for instruction (Bialo & Sivin, 1990). The results of Hollar's study indicated that the use of graphing calculators helped students gain a better understanding of the function concept. The Cognition and Technology Group at Vanderbilt (1992) conducted a large-scale research using interactive laser disk. Both of these studies were compared to traditional instruction. Beneficial effects were found in areas of problem solving skills and student attitudes. A study by Hopson (1998) supported a technology-enhanced learning environment in the development of higher order thinking skills. The technology used in his research was the computer. As computer technology infuses our society and becomes more and more a part of work and daily life, it is recommended that this technology be incorporated into education (NCTM, 1989, 1998).

Another finding of this study was that students that used the Topocam in a technology-enhanced unit on slope were engaged in learning. Jones and his colleagues looked to the best available research on learning and on the work of Barbara Means when refining the Indicators of Engaged Learning (1994). The evaluation of technology should be measured by the degree that students are engaged in learning while using that technology (Mean, 1993). Positive results are likely when students are engaged (McDonald, 1998).

Limitations of the Study

The following factors would be considered limitations of this study.

1. The number of students participating in the study was small. Some data were lost due to student absences. A larger group would increase the reliability of the conclusions.
2. The study was limited to intact classes.
3. The study was for two weeks. A longer unit of study could produce more definitive results.
4. The design of the study makes the degree of benefit attributed to the Topocam undeterminable. Further research is necessary.
5. All students were aware that they were in a research because they signed consent forms. This awareness may have caused a change in their behavior known as the Hawthorne effect.
6. The existence of a pretest may have had an effect on the posttest performance. This is called pretest sensitization (Gall et al., 1996).

Implications for the Classroom

Emerging computer technology requires responsible investigation concerning the extent of educational benefits. The integration of current technology tools into instruction can engage students in the learning process. The Topocam provided the students the opportunity to manipulate mathematical phenomenon, specifically slope in this study. Likewise, there is evidence from this study that the Topocam is effective as an educational tool. The characteristics of the student population and the influence of the teacher present variables to the learning process.

Recommendations for Further Research

New computer technology provides avenues for exploration, seeking to tap their full potential. The results of this study suggest that further research is warranted in the area of technology as a means to apply and give meaning to mathematical concepts. A continuation of this study is recommended. A natural extension would be a similar study utilizing an experimental design in order to help determine the extent of the Topocam's effectiveness. A larger sample and longer time period than used in this study are strongly recommended. Also, teacher observations would help analyze the teacher's effect on learning as well. By utilizing another measure several weeks after the conclusion of the study, students' retention of knowledge and transfer could also be investigated.

Other uses of the Topocam also offer research opportunities, such as the potential in the area of relative motion.

Studies are recommended that focus on the effects of the Topocam or other technology with students of varying abilities and backgrounds. There were indications that point to the possibility of the Topocam as a means of engaging students that have had difficulty with mathematics or that have become disengaged with learning. Factors such as discipline and attendance records would be indicators of engagement/disengagement.

This research began only a small part of evaluating the effectiveness of the Topocam as an educational tool. The field is wide open for in depth research with the Topocam. Many of these areas for further evaluation of educational products were presented by Edwards et al. (1997). They include:

- Number of people it would benefit
- Cost in money, teaching time, student time, and upkeep
- Extent of benefit
- Durability of educational gain
- Generalizability over different students, teachers, and cultures.

APPENDIX A

GLOSSARY FOR TABLE 1

Glossary for Table 1

Vision of Learning
Responsible for learning – learner involved in setting goals, choosing tasks, developing assessments and stands for the tasks;
Strategic – learner actively develops repertoire of thinking/learning strategies
Energized by learning – learner is not dependent on rewards from others; has a passion for learning
Collaborative – learner develops new ideas and understanding in conversations and work with others

Tasks
Authentic – pertains to real world, may be addressed to personal interest
Challenging – difficult enough to be interesting but not totally frustrating, usually sustained; requires creative and/or critical thinking
Integrative/Interdisciplinary – involves integrating disciplines to solve problems; address issues

Assessment
Performance-based – involving a performance or demonstration, usually for a real audience and useful purpose
Generative – learner constructs the knowledge and artifacts assessed, ideally learner generates performance criteria and contributes to overall assessment plan
Seamless and ongoing – assessment is part of instruction and vice versa; students learn during assessment
Equitable standards – assessment is culture fair and standards apply to all

Instruction/Model
Interactive – teacher and students actively engaged in learning with each other and with instructional resources
Generative – instruction oriented to constructing meaning; providing meaningful activities/experiences

Learning Context
Collaborative – instruction conceptualizes students as part of learning community; activities are collaborative within and across classroom boundaries
Knowledge building – learning experiences set up to bring multiple perspectives to solve problems such that each perspective contributes to shared understanding for all; goes beyond brainstorming to construct meaning
Empathetic – learning environment and experiences set up valuing diversity, multiple perspectives, strengths

Grouping
Heterogeneous – small groups involve persons from different ethnic cultures and backgrounds, genders, and abilities
Equitable – small groups organized so that over time all students have challenging learning tasks/experiences
Flexible – different groups organized for different instructional purposes so each person is member of different groups based on need and/or interests

Teacher Roles
Facilitator – stimulates and monitors discussion and project work but does not control; negotiates with students and others

Guide – helps students to construct their own meaning by modeling, mediating, explaining when needed, redirecting focus, providing options
Co-Learner/Co-Investigator – teacher considers self as learner; willing to take risks to explore areas outside his or her expertise; cc collaborates with other teachers, students, and practicing professionals

Student Roles
Explorer – students have opportunities to explore new ideas, new tools; push the envelope in ideas and research; engages in frequent discovery-oriented, open-minded activities
Cognitive Apprentice – learning is usually situated in relationship with mentor who coaches students to develop ideas and skills that simulate the role of practicing professionals (e.g., engage in real research); student observes, applies, and refines through practicing the thinking processes of the practitioner
Teacher – students encouraged to teach others in formal and informal contexts
Producer – students develop products of real use to themselves or others

Note. From Designing Learning and Technology for Educational Reform (p. 73), by B. F. Jones, G. Valdez, J. Nowakowski, and C. Rasmussen, 1994, Oak Brook, IL: NCREL. Copyright 1994 by NCREL. Reprinted with permission.

APPENDIX B

UNIT ON SLOPE

Regular Classroom Activities

Day	Learning Objectives	Activities
1	Pretest	Pretest Intro to Topocam (See Topocam activities)
2	To develop an understanding of the concept of slope as a rate of change	Teacher puts up a transparency of a graph. The graph is of a student walking to a friend's house. The graph includes three different rates, plus two constant rate periods. Students discuss the graph in pairs and answer three questions: How fast did the student walk? Was the student's speed the same throughout the trip? What were the different rates that the student traveled? Group discussion of the analyses. Teacher explains rate (rise over run) as slope. Discuss what would happen to the graph if the rate was changed. Determine all of the rates for the graph of a student walking to a friend's house.
3	To learn the concept of slope as rise/run and as change in y/change in x	Review previous day. Teacher demonstrates determining slope by counting the units to move first vertically, then horizontally. Do two constant slope calculations together with the class by counting rise over run. Give the students one to test their understanding. Introduction change in y over change in x. Do these four examples together: A (5,8) and B (7,10), X(-37) and Y(-7,-2), M(5,3) and N(5,9),P(-2,7 and Q(5.7).
4	To recognize slope as a description of change in different situations	Teacher presents four new graphs of people eating popcorn. Create a story for the first graph. Students write paragraphs describing what could be happening in each graph. Share stories with the class. Students match seven graphs to possible situations. Given two blank graphs, students describe what could be happening to hand in.

5	To recognize that the slope of a line is the same everywhere along the line	Go over stories that students handed in from yesterday. Review the formula rise/run. Given graph paper, students sketch graphs with the following steepnesses: 2/3, 2/5, 4/2, 3/1, 2/2, 0/2. Go over answers. Given different stair step diagrams, students match them to the correct slope (3/3, 3/5, 5/5, 5/3, 1/3, 3/1).
6	To be able to calculate slope of straight lines, including horizontal and vertical lines	Review the formula change in y/change in x. Students determine slope of six straight lines on coordinate grids that include a horizontal and vertical line (show their work using change in y/change in x). Go over the answers. Assign six more lines to find the slope and one story to graph and find the slope (show their work). Students hand in this paper. Extra practice graphing coordinates and finding slope – two puzzle worksheets.
7	To find patterns in slopes of lines	Review rise/run and change in y/change in x to find slope. Worksheet with four problems to graph coordinates and find slope. Use the graphing calculators to graph linear functions and look for patterns in slope.
8		Topocam Symposium (See Topocam activities)
9	Review	Topocam Symposium (See Topocam activities) Review
10	Review/Posttest	Posttest

APPENDIX C

TOPOCAM ACTIVITIES

Topocam Activities: Slope Unit Time Line

Students take pre-test .... 20 minutes, class 1

Introduction presentation to whole group .... 20 minutes, class 2
Divide into teams of 4*, design team object.. 20 minutes, class 2
Explain team agenda to whole group... 10 minutes, class 2

Each team takes their series of photos ....90 minutes, classes 3, 4, 5, 6, 7
Rest of class has class as usual

Explain symposium format to whole group... 10 minutes, class 8
Each team plans their symposium presentation .... 40 minutes, class 8

Symposium ....class 9
Each team has minimum of 4 minutes, maximum of 7 minutes for their presentation

Review & Post-test .... 20 minutes, class 10

*Ideal team size, a team of 3 or 5 will be used if the class does not divide evenly by 4

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Series of Topocam Photos for Slope Unit

1. Photo #1: Take baseline photo of team object.

   There will be 3 different baseline photos. With 6 teams, two teams will have each baseline. This will allow for comparison of common experiments in addition to comparison of different experiments.

Teams	Distance of Object from Camera	Speed
1 & 4	60 cm	10.5 cm/sec
2 & 5	90 cm	15.75 cm/sec
3 & 6	120 cm	21 cm/sec

2. Make visual prediction for photo #2. Each team will be assigned a different speed at which to take their photo. All other variables will be the same as in the baseline photo.

Team	Distance of Object from Camera	Speed
1	60 cm	5.25 cm/sec
4	60 cm	21 cm/sec
2	90 cm	7.875 cm/sec
5	90 cm	31.5 cm/sec
3	120 cm	10.5 cm/sec
6	120 cm	42 cm/sec

3. Photo #2: Take assigned experimental photo. Do analysis on prediction. Do comparison of photos and data (what's the same, what's different)

4. Set up ratio table (geometric spreadsheet on paper) which will include slope.

5. Do a comparison of the 2 photos (worksheet to fill out). This comparison will help give ideas for Photo 3 as well as aid in the prediction of Photo #3.

6. Decide on variable for Photo #3. Pick a new distance (using one of the speeds from the two prior photos) or new speed (keeping the distance the same). Team decides together.

7. Predict photo #3. Do a prediction in ratio table, too. (Or you can do ratio table first)

8. Take photo #3.

9. Do analysis of prediction, both visually and in the ratio table.

In the symposium, the three teams that used "half the baseline speed" should be sure to compare notes while the three teams that "doubled the baseline speed" should compare notes. In addition, the two teams that had the same distance should compare notes.

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APPENDIX D

TOPOCAM JOURNAL

Journal, p. 1

Mathematicians are Good at:

Questioning and wondering

Communicating

- Describing
- Measuring
- Predicting

Analyzing

- Categorizing
- Classifying
- Comparing
- Observing
- Finding Patterns

Being Precise, Accurate, and Careful

Thinking Creatively and Cleverly

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Journal, p. 2

Topocam Job Rotation Chart

Team Member	Picture 1	Picture 2	Picture 3	Picture 4
Red	Data expert	Lighting director	Computer operator	Object assistant
Blue	Object assistant	Data expert	Lighting director	Computer operator
Green	Computer operator	Object assistant	Data expert	Lighting director
Yellow	Lighting director	Computer operator	Object assistant	Data expert

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Journal, p. 3

Topocam Job Descriptions

Data expert

- Write down all the data that the computer operator gives you
- Write down all the data that the object assistant gives you
- Share all the data with your teammates so that they may write it down in their journals

Object assistant

- Set up the object to be photographed
- Measure the distance between the Topocam and the object
- Report the distance to the data assistant
- Watch to make sure no one touches or wiggles the cables and the table

Computer operator

- Do all the typing and mouse control required for the photograph
- Tell the lighting director when it's time to turn on and turn off the light
- Select the filename for the photograph (pick a name or word that is 8 letters or less)
- Report all data (both before and after the photograph) to the data expert

Lighting director & printing person

- When it's time to turn on the light, make sure the object assistant and all teammates are safely out of the way
- Turn the light on and off when computer operator tells you
- Take pictures out of printer as they are ready
- Punch holes in paper for teammates when photos are dry
- Hand out photos making sure each teammate gets one
- Put paper in printer if needed

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Journal, p. 4

Prediction and Analysis Page

Experiment #: _____ Description: _______________________________________

Before you take your photo, draw or write your prediction of what you think it is going to look like:

After you take your photo, draw or write what it actually looked like:

Compare your prediction and the actual photo. *How was the actual photo different from what you thought it would look like? What was just as you expected? What surprised you?:*

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Journal, p. 5

Method 6 Data Collection Sheet

Experiment #: ______Experiment Description: ________________________________

	Photo # _____	Photo # _____
Distance of Object from Camera:	_____ centimeters (cm)	_____ centimeters (cm)
Camera Starting Position:	_____ centimeters (cm)	_____ centimeters (cm)
Camera Stopping Position:	_____ centimeters (cm)	_____ centimeters (cm)
Camera Speed:	_____ cm per second	_____ cm per second
After you take the picture:		
Lines Scanned:	_____ lines	_____ lines
Total Scan Time:	_____ seconds	_____ seconds
Filename:	_ _ _ _ _ _ _ _ _.bmp	_ _ _ _ _ _ _ _ _.bmp

Notes and observations:

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Journal, p. 6

Your name ________________________________

A Comparison of Two Topocam Photos

______________________________ and ______________________________

file name of baseline photo file name of photo with changed variable

what stayed the same . . .	what changed . . .

Other observations . . .

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Journal, p. 7

Analysis of Slope in Topocam Photos

Determine Your "Path of Analysis"

- Pick 2 points next to each other on the line.
- Pick one for your starting point, the other will be your ending point.

- Put your pencil on the starting point, choose whether to go up or down (if there's a choice).
- Trace the step in the vertical direction. When the vertical line intersects the horizontal line, there will be only one way that you can move your pencil without picking it up off the paper. Trace the horizontal portion of the step until you reach the endpoint.
- In the chart below, record the path between the two points.

Starting point	
Up or down?	
Left or right?	
Ending point?	

Take measurements

- Use the same step you traced in the path above when measuring the original object and the two photos.

	Original object	Baseline Photo	Photo #2
Direction of vertical step Use information from "path analysis" above – "up" is positive, "down" is negative			
Height of vertical step			
Direction of Horizontal step Use information from "path analysis" above – "right" is positive, "left" is negative			
Length of horizontal step			

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Journal, p. 7

Analysis of Slope in Topocam Photos, continued

Determine the slope

- Slope is the ratio of y to x; it is the ratio of the vertical to the horizontal.
- Use the information in the second table to do these calculations:

	Original object	Photo #1	Photo # 2
Fraction form of the slope <u>y</u> = <u>+ or – height of vertical step</u> x + or – length of horizontal step			
Decimal form of the slope			

Comparison of slope—steepness

- *Visually (just by looking)* compare the slope of the line in the original object and the slope of the line in photo #1. Are the two slopes the same? If not, which slope appears steeper?

- *Mathematically (using the decimal form of the slope*) compare the slope of the line in the original object and the slope of the line in photo #1. Are the two slopes the same? If not, which slope is larger?

- *Visually (just by looking)* compare the slope of the line in photo #1 and the slope of the line in photo #2. Are the two slopes the same? If not, which slope appears steeper?

- *Mathematically (using the decimal form of the slope)* compare the slope of the line in the original object and the slope of the line in photo #2. Are the two slopes the same? If not, which slope is larger?

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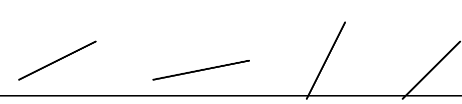
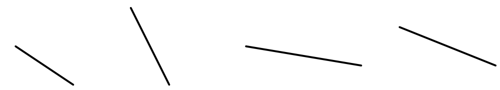
Journal, p. 8

Analysis of Slope in Topocam Photos, continued

Analysis of slope—direction

When a line "leans to the right", its slope has a positive direction. (If you start on the lift side of a line and go to the right, if you	

go “uphill’, the slope is positive.)	
When a line “leans to the left”, its slope has a negative direction. (If you start on the left side of a line and go to the right, if you go “downhill”, the slope is negative.)	

Visually (just by looking) what is the direction of the slope in the original object?

Circle one: positive negative

Mathematically (using the decimal form of the slope) what is the direction of the slope in the original object?

Circle one: positive negative

Visually (just by looking) what is the direction of the slope in photo #1?

Circle one: positive negative

Mathematically (using the decimal form of the slope) what is the direction of the slope in photo #1?

Circle one: positive negative

Visually (just by looking) what is the direction of the slope in photo #2?

Circle one: positive negative

Mathematically (using the decimal form of the slope) what is the direction of the slope in #2?

Circle one: positive negative

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Journal, p. 9

Presentation Checklist

_____ introduce yourself, tell team name

_____ show team staircase

____ tell direction of slope (positive or negative)

____ tell speed of camera in your experiment ____ cm/sec

____ tell an interesting observation about your experiment (look at your comparison sheet)

____ give students their sheet

____ show students their choices

____ when students are sure of their “final answer”, collect their game sheets

____ when all contestants have turned in their sheets, reveal the correct answers

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Journal, p. 10

<table>
<tr><td colspan="2">The ____________________ team photographed their staircase at _____ cm/sec. Which of the following photographs most closely resembles the staircase in their second photograph?</td></tr>
<tr><td>A.</td><td>B.</td></tr>
</table>

C.	D.

Is that a guess, or are you sure? How do you know that answer?

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Journal, p. 11

(Display three photos taken with the Topocam: one taken at 10.5 cm/sec, one taken with the camera in a fixed position, and one taken in reverse at 10.5 cm/sec.)

Look at the three actual photos taken by the Topocam. The same object was photographed in all three. The first is a baseline photo. Pick one of the other two photos and describe how it could have been made. Circle the photograph that you pick.

Compare the slope in the photo you picked to the slope in the baseline photo.

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Journal, p. 12

In the Topocam photos that we took, slope was affected by the speed of the camera. List as many other situations in life where slope is affected. (The more you can list, the better.)
Tell what causes the change in slope.

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APPENDIX E

PRE/POSTTEST

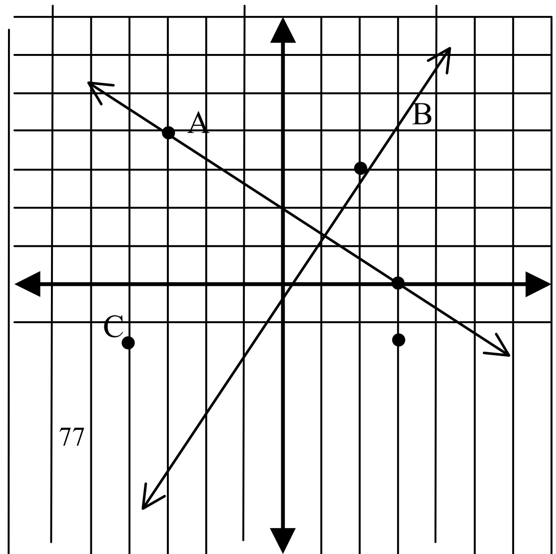
Algebra **Name:___________________**

Slope test Spring 2000

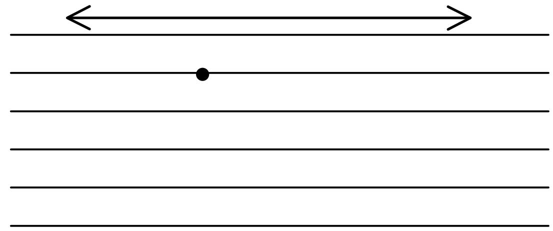
Name the slope of each line.

______1. Line A

______2. Line B

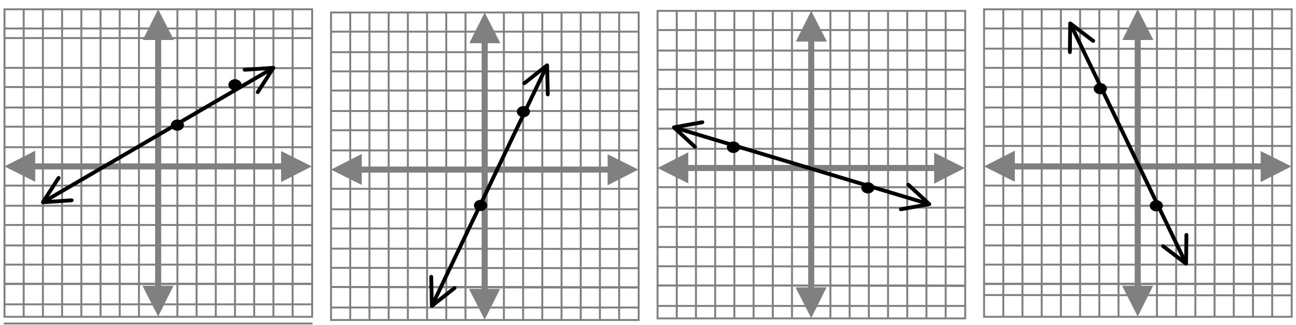


______3. Line C



Use the following graphs for questions 4-11. Each question may have more than one answer.

Line A | Line B | Line C | Line D



______4. Which lines have positive slopes?

______5. Which lines have negative slope?

______6. Which line has the greatest slope?

______7. Which lines have slopes that are between 0 and 1?

Find the slopes of the graphs using the points marked as reference.

______8. Line A

______9. Line B

______10. Line C

______11. Line D

Determine the slopes of the lines connecting the following points.

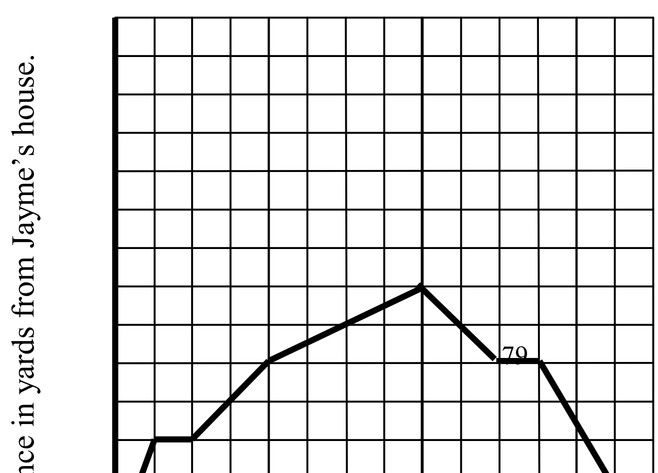
______12. A(5, 8) and B(7, 10)

______13. X(-3, 7) and Y(-7, -2)

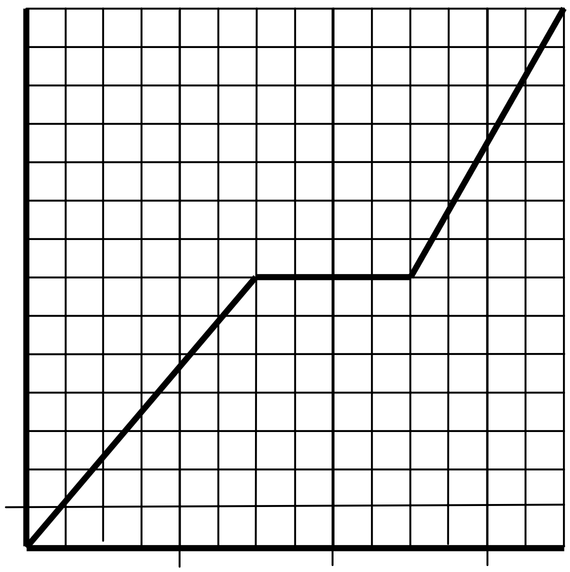
______14. M(5, 3) and N(5, 9)

______15. P(-2, 7) and Q(5, 7)

The following graph represents Jayme's walk with her dog this morning. Write a story description of the walk. Be sure to explain the different slopes on the graph and include the times when any changes occurred.



Write a story that would describe the behavior of the graph below. You may use any situation or characters. Please keep your responses “school appropriate”, but keep in mind that points will be awarded for creativity.



APPENDIX F

ENGAGED LEARNING PROFILE TOOL

Adapted from Engaged Learning and Reform Instruction

Indicators of Engaged Learning Checklist

Variable	Indicator for Engaged Learning	Frequency & Description			
		10	20	30	Describe an observation
Vision of Learning	Responsible for Learning Strategic Energized by Learning Collaborative				
Tasks	Authentic Challenging Multidisciplinary				
Assessments	Performance-Based Generative Seamless and ongoing Equitable				
Instructional Models	Interactive Generative				
Learning Context	Collaborative Knowledge-building Empathetic				
Grouping	Heterogeneous Equitable Flexible				
Teacher Roles	Facilitator Guide Co-Learner/Co-Investigator				
Student Roles	Explorer Cognitive Apprentice Teacher Producer				

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APPENDIX G

RESEARCH CONSENT

Dear Parent or Guardian,

Hello, my name is Mrs. Beck and I am a doctoral candidate at the University of North Texas. I will be conducting a research project designed to study how a specific technology, the Topological Panoramic Camera (Topocam), influences the learning of algebra concepts. Data will be collected from a unit that teachers will be doing on slope in algebra. The unit will be taught by the regular classroom teacher with assistance from a consultant on the Topocam. As part of this unit there will be activities using the Topocam. The Topocam is a computer-controlled camera that moves on a modular track while it scans a scene through a vertical slit. Students can program the speed of the camera and frequency of pictures. They can then witness effects of time and motion in the image created by the camera. The Topocam is owned by the school and may be useful in math, science, and other areas of instruction. The goal of the study is to examine the usefulness of the Topocam in teaching slope and related concepts in algebra. The study will take place between January 18 and February 5, 2000.

I request permission for your student to participate in this study. Since the unit is part of the regular instruction, I am simply asking permission to use data collected from the unit. The unit includes a pre/post test and a journal. I would also like to observe the indicators of student engagement while doing Topocam activities. I will not use the students', teachers', nor school names in this study. Individual information will be used only for matching pre- and posttest data.

Research on emerging technologies, such as the Topocam, hold value in helping understand the impact and effectiveness of technology in education. There is no foreseeable risk to the student in this study.

Your decision whether or not to allow your student to participate in the research will in no way affect the student's standing in his or her class. Also, the student may withdraw from the research at anytime without penalty or prejudice. At the conclusion of the study, a summary of group results will be made available to all interested parents and teachers. Should you have any questions or desire further information, please call me at 716-9929.

Thank you for your cooperation and support.
Sincerely,

Elaine Beck

This project has been reviewed and approved by the University of North Texas Committee for the Protection of Human Subjects (Phone: 940 565-3940).

Please sign & return one of these letters. The other copy is for you to keep.
I grant permission for my student, ___________________________ , to participate in this project.
Parent's signature: ______________________________

Date: ______________________

Student Consent Form

I understand that Mrs. Beck is conducting a research project on a new technology called the Topocam. The Topocam is a computer-controlled camera that moves on a modular track while it scans a scene through a vertical slit. We will be able to program the speed of the camera and then witness effects of time and motion in the image created by the camera. The Topocam is owned by the school and may be useful in math, science, and other areas of instruction.

Mrs. Beck's research will be based on the tests and a journal we will do in a unit on slope in algebra class starting in mid-January. The unit lasts a couple weeks. She is looking at the benefits of this technology in helping us learn algebra. I understand that my name will not be used in the results of this study.

I also understand that this is a unit that all students will be doing in class anyway. Mrs. Beck is just asking permission to use the results from the tests, journal, and observations to help identify the effects of a technology on learning algebra. Good research is important in order to help improve instruction. The research project will take place in a normal class environment and does not present any risks.

My decision to participate in the research does not effect my grades. I can decide not to be included in the research at any time without being penalized. At the conclusion of the study, I can have a summary of group results if I like.

This project has been reviewed and approved by the University of North Texas Committee for the Protection of Human Subjects (Phone: 940 565-3940).

I would like to be included in Mrs. Beck's research project.

Student signature: ________________________________

Date: __________________

A copy of this letter is attached for you to keep.

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